Australian Government
Department of Industry, Innovation and Science
Business Cooperative Research Centres Programme
National Acoustic Laboratories
THE HEARING CRC

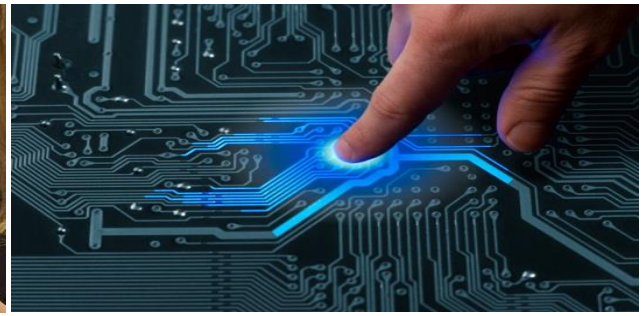
Determining threshold levels in adult Nucleus cochlear implant users by recording cortical auditory evoked potentials with a two-channel clinical system

Bram Van Dun[1,2], Nicky Chong-White[1,2], Paola Incerti[1,2,3], Joaquín Valderrama[1,2], Robert Cowan[1,3]

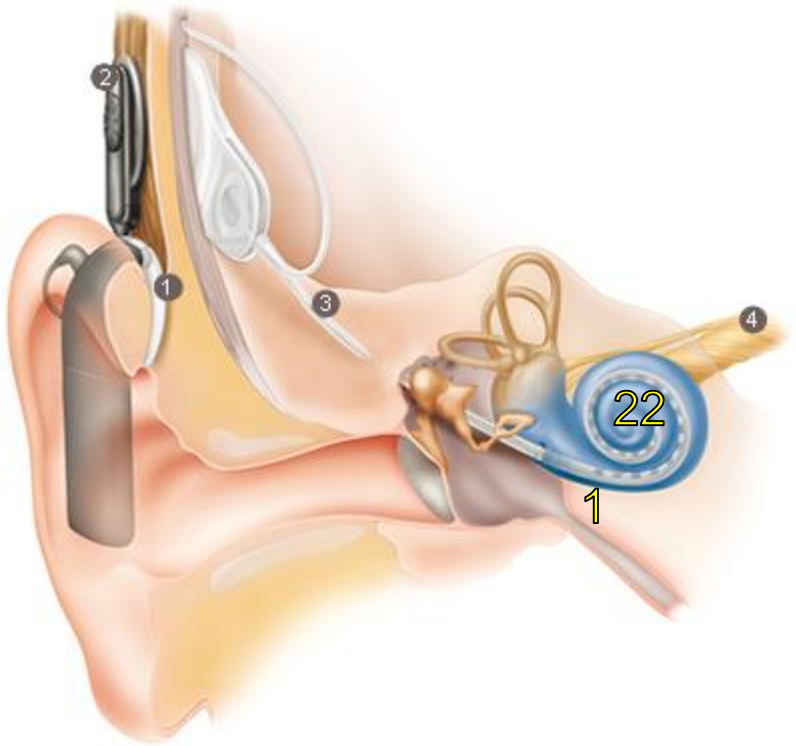
[1] *The HEARing Cooperative Research Centre, Melbourne*
[2] *National Acoustic Laboratories, Sydney*
[3] *Melbourne University, Melbourne*

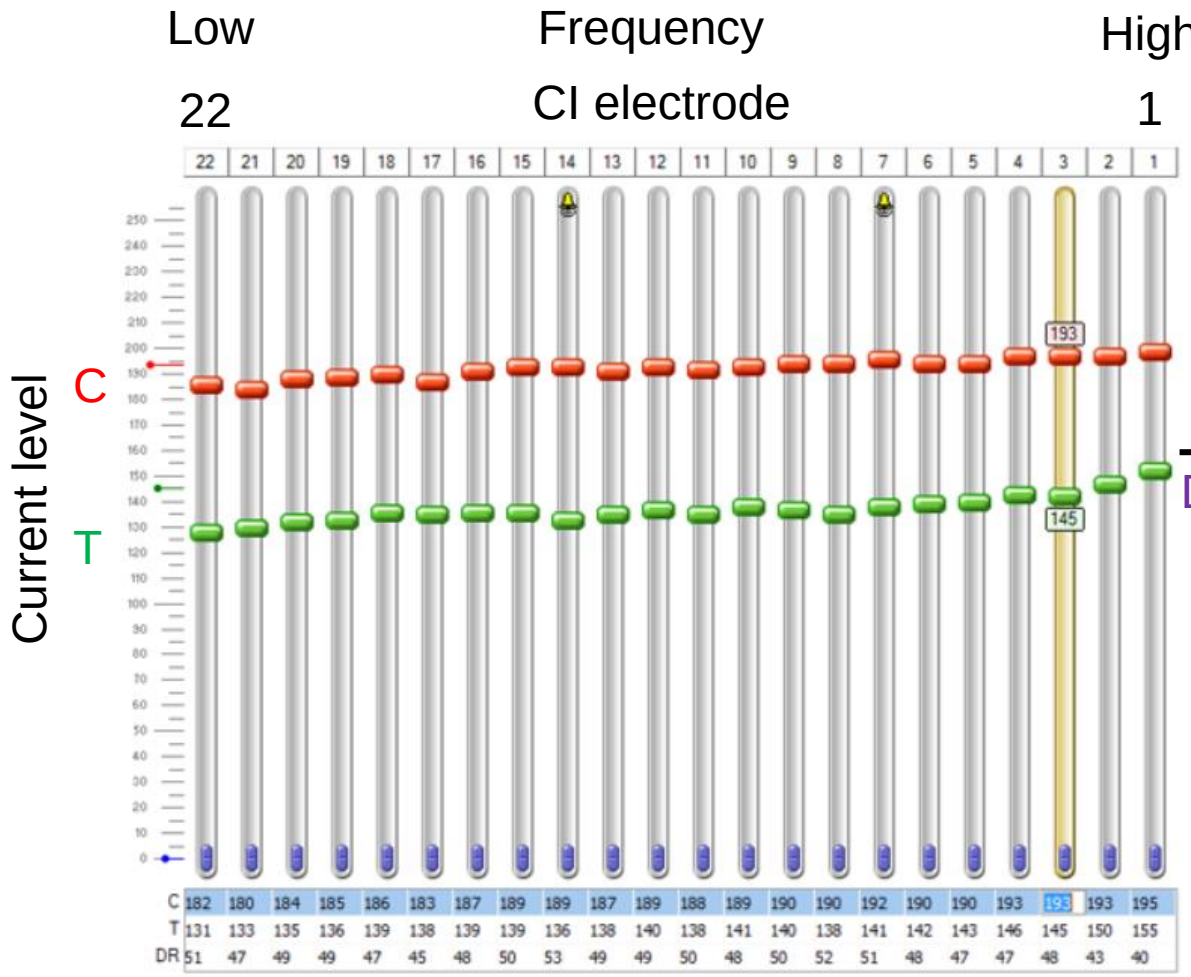
Audiology Australia Conference 2018

creating sound value™

Fitting cochlear implants





Comfortable (C) – Threshold (T)

Dynamic range (DR)

T-level: Threshold level

C-level: Most comfortable level

Source for both images: Cochlear

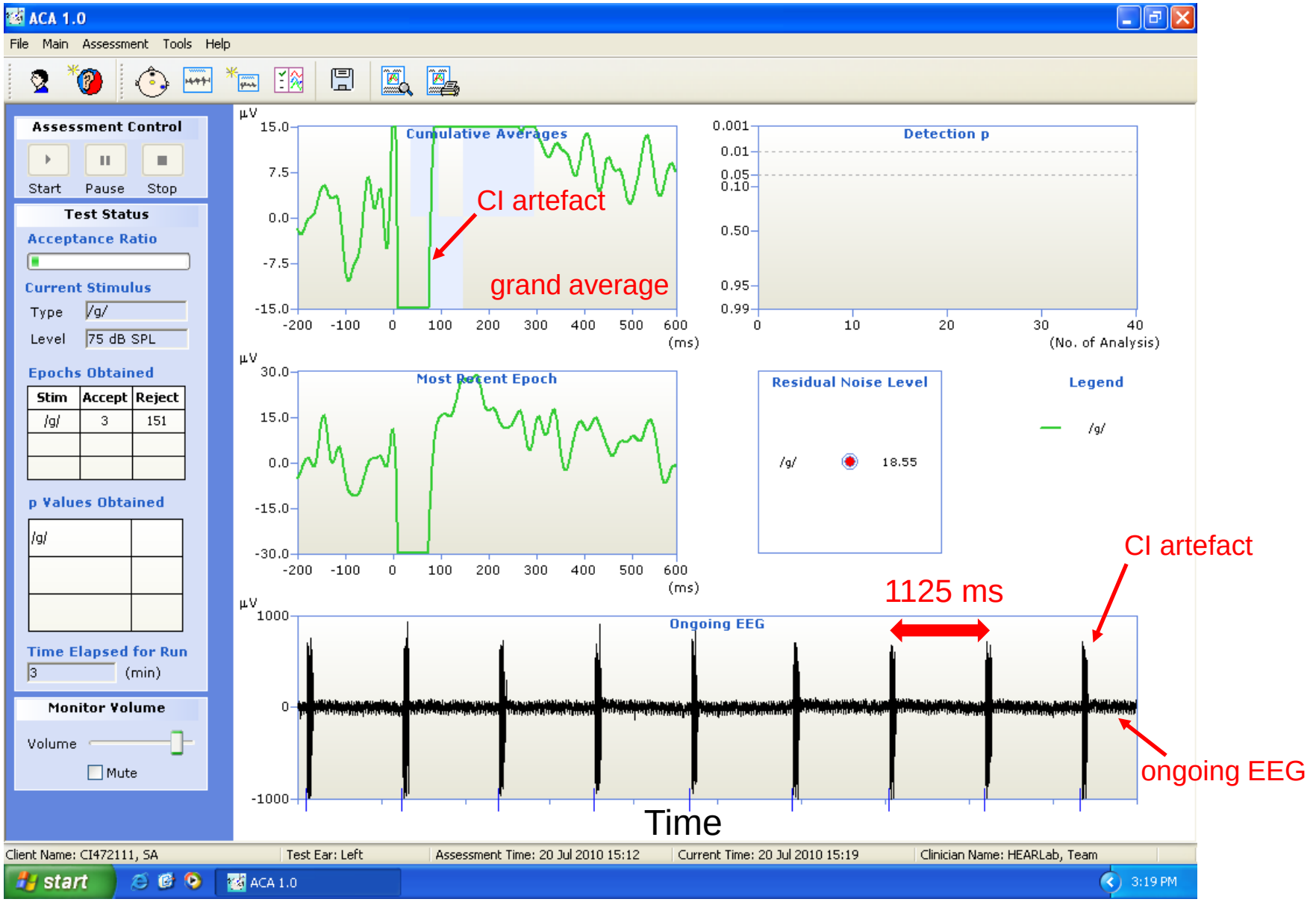
Objectively determining thresholds on a CI electrode

- Electrically evoked Compound Action Potential (eCAP) ~ ABR Wave I
  - Poor correlations and not always recordable
    - Average eCAP thresholds at 91% of dynamic range (Brown et al., 2000)
    - Meta-analysis of 29 studies: r = 0.58 and 0.61 for T- and C-levels (de Vos et al., 2017)
  - Not extremely reliable for fitting a CI, so caution needed
  - Behavioural component seems to be required. Problematic for infants
  - Only evaluates early part of auditory system

- Why not use CAEPs instead?
  - Visram et al. (2015) found a correlation of r = 0.93
  - But, involves 64 EEG channels and hours of recording

Can we do the same with a clinically usable system?

Problem


ACA 1.0
File Main Assessment Tools Help
Assessment Control
Start Pause Stop
Test Status
Acceptance Ratio
Current Stimulus
Type /g/
Level 75 dB SPL
Epochs Obtained
Stim Accept Reject
/g/ 3 151
p Values Obtained
/g/
Time Elapsed for Run
3 (min)
Monitor Volume
Volume
Mute
Cumulative Averages
CI artefact
grand average
Detection p
(No. of Analysis)
Most Recent Epoch
Residual Noise Level
/g/ 18.55
Legend
/g/
Ongoing EEG
1125 ms
CI artefact
ongoing EEG
Time
(ms)
Client Name: CI472111, SA
Test Ear: Left
Assessment Time: 20 Jul 2010 15:12
Current Time: 20 Jul 2010 15:19
Clinician Name: HEARLab, Team
start
ACA 1.0
3:19 PM

Current research on removing CI artefacts

- Varies in clinical applicability
  - Gilley et al (2006): use of 64 channel electrode cap + fancy processing
  - Friesen et al (2010): different interstimulus intervals
  - Mc Laughlin et al (2013): single channel high-sample + artefact fitting
  - Presacco et al (2017): use longer stimuli

Research questions

Using a clinical CAEP recording system:

- Can we suppress CI artefacts sufficiently?
- What corrections to apply to CAEP threshold to obtain a threshold T-level?
- What are the correlations between CAEP threshold and T- and C- levels?
- How does this compare with the eCAP?

Methods

longer stimulus to suppress artefact successfully

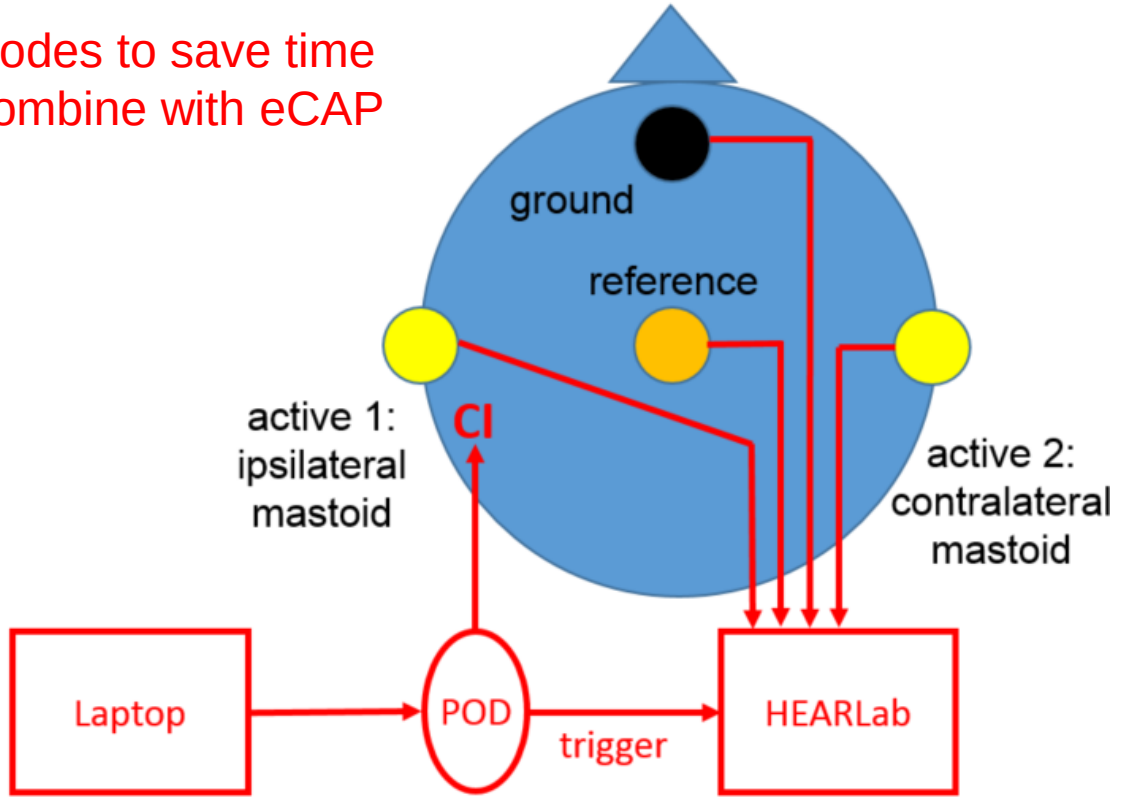
- 500 ms burst of pulses
  - 900 pps
  - 25-8-25 µs pulse
  - CI electrodes 20, 11 and 3
- Stimulus levels
  - -20 / 15 / 30 / 50 / 70 / 100% of dynamic range

only use 3 CI electrodes to save time and interpolate or combine with eCAP

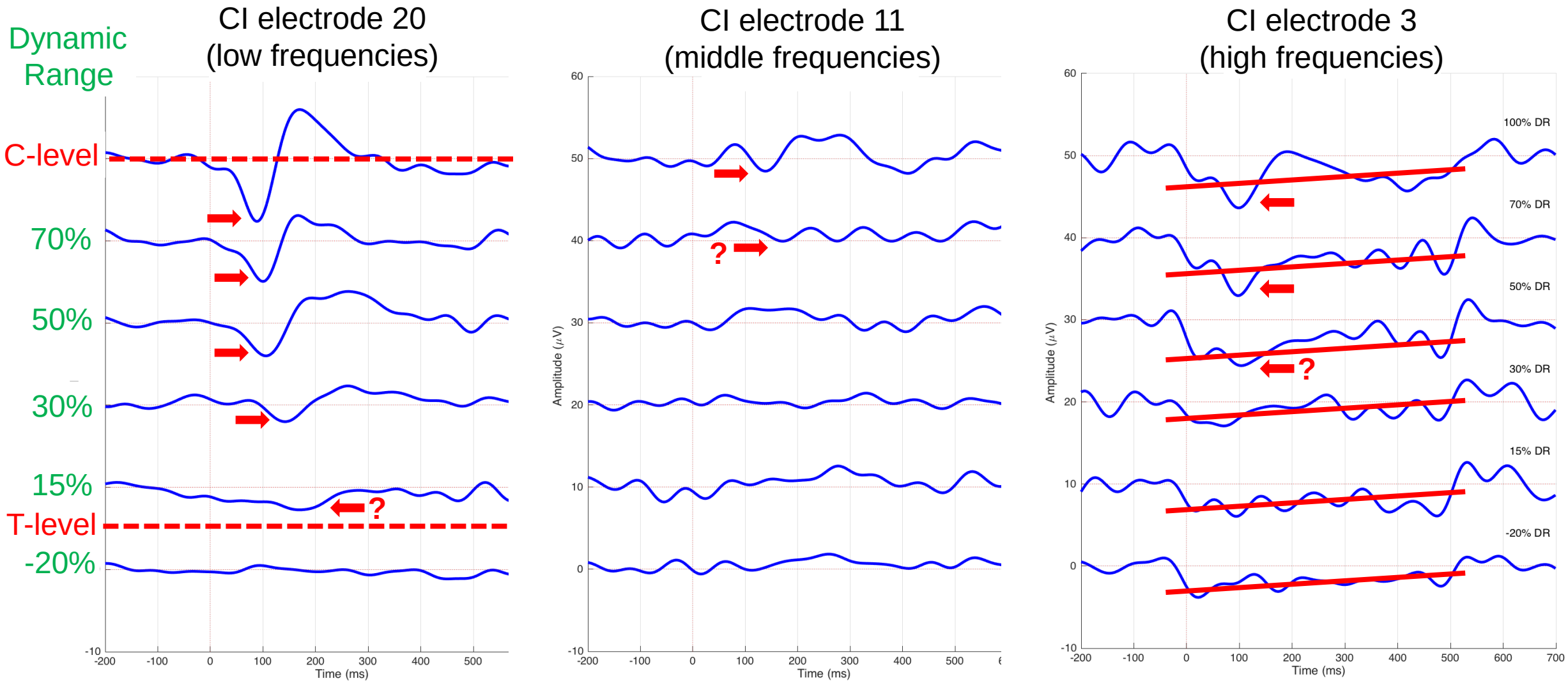
threshold estimation

- Other parameters
  - 100 presentations per recording
  - 2 seconds SOA
  - Direct stimulation
  - 0.33 Hz – 30 Hz filtering
  - 16 kHz sampling

- 14 adults with Nucleus CI, 10 retest



Results (1)



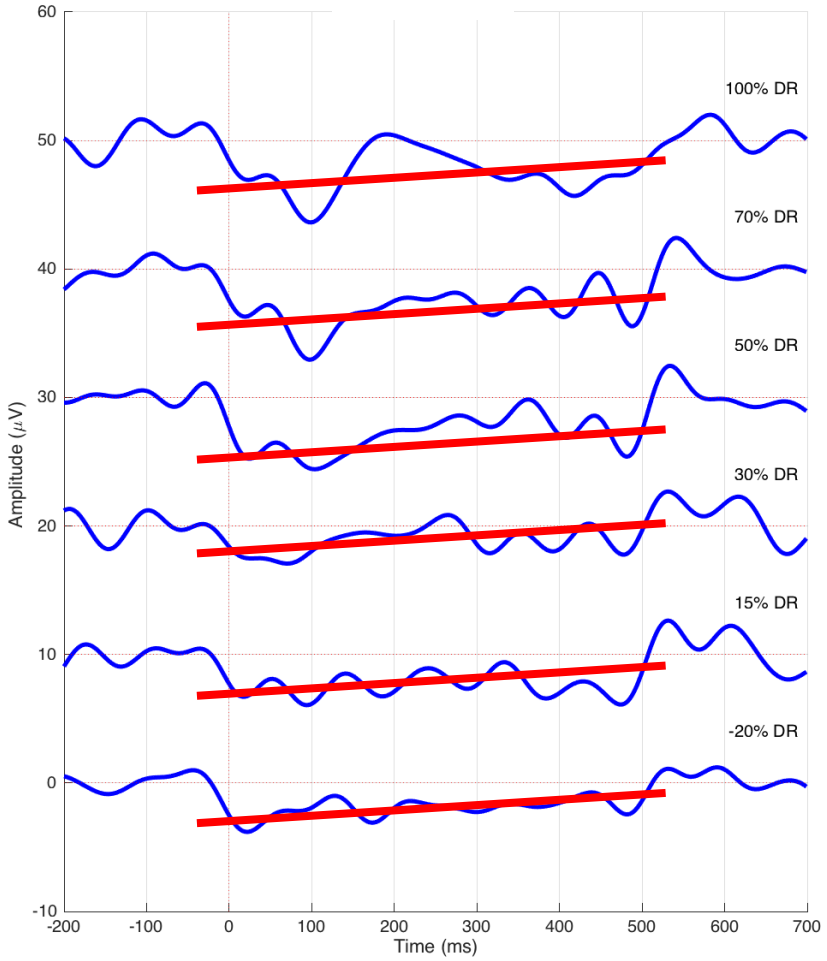
Threshold at 30% DR

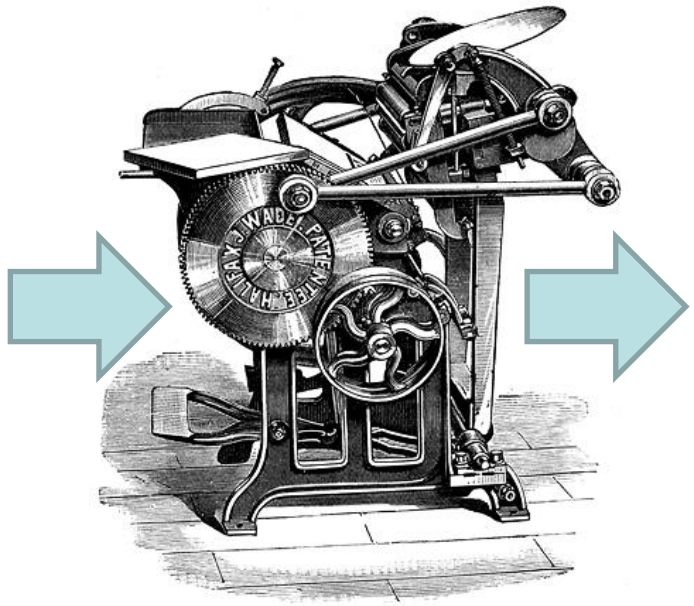
Threshold at 100% DR

Threshold at 70% DR

Results (2)

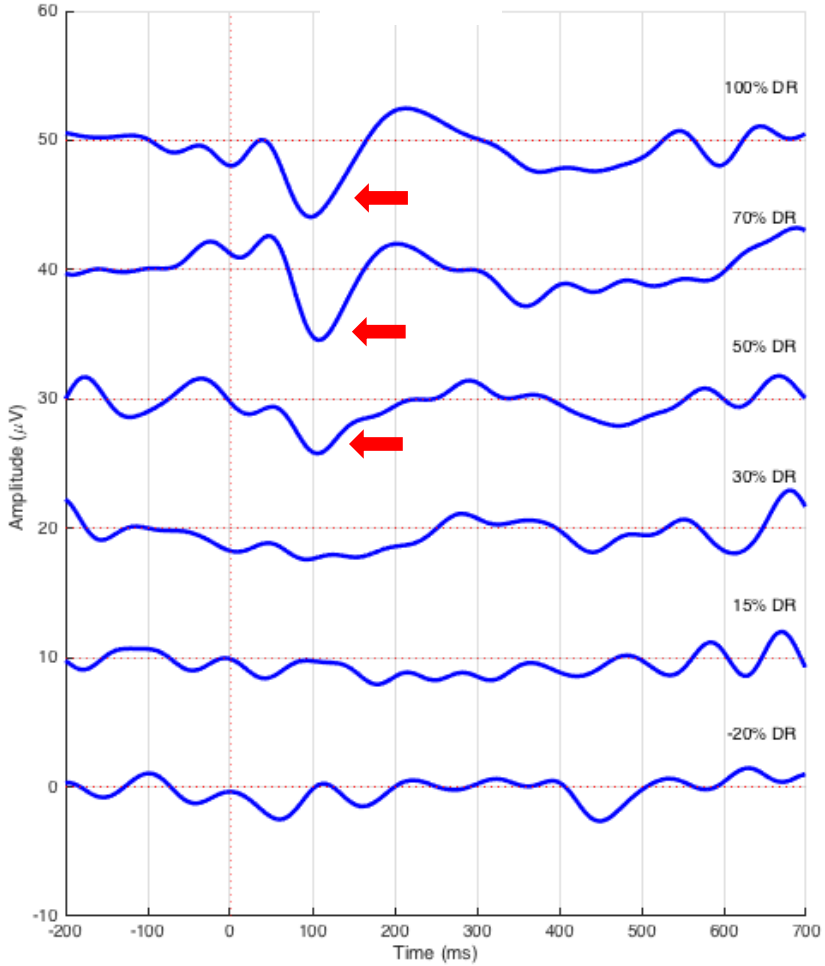
Before artefact suppression





Artefact suppressor

After artefact suppression

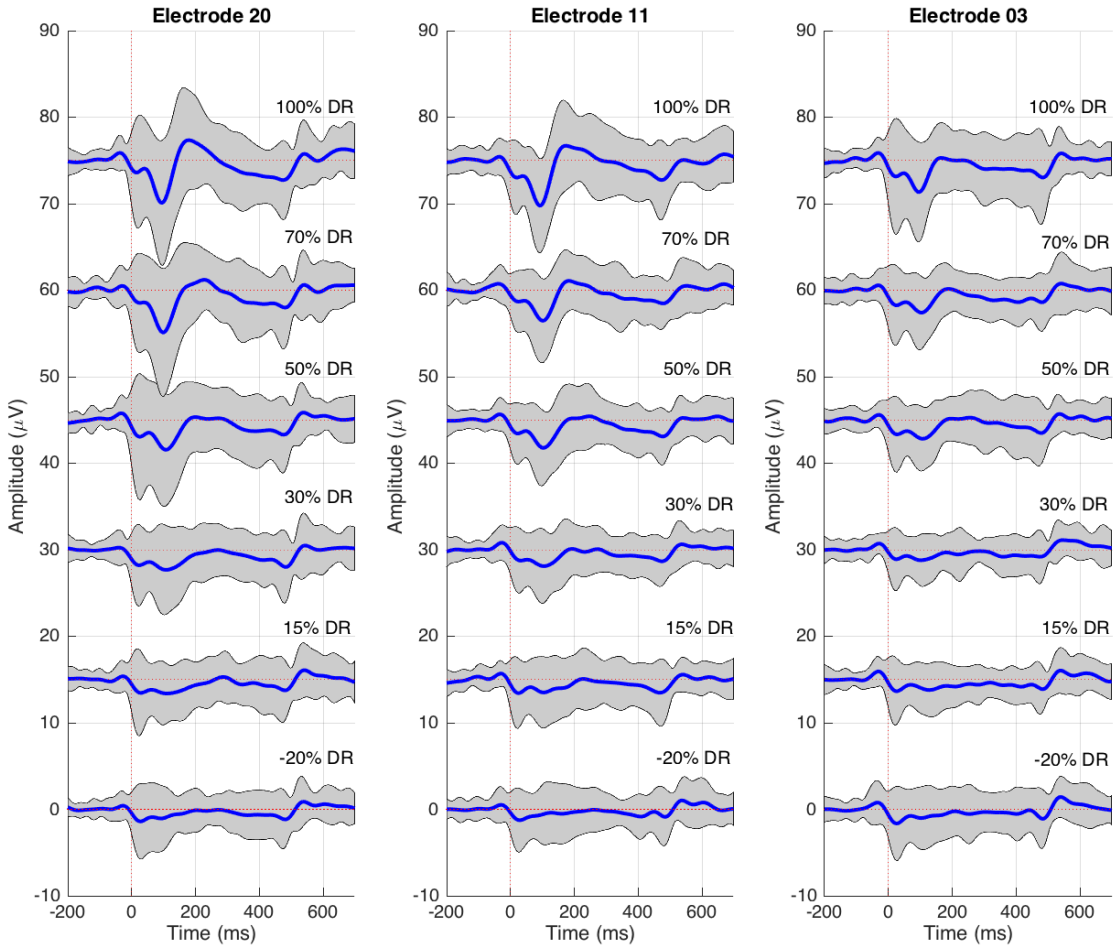


Threshold at 50% DR

Source: Pinterest

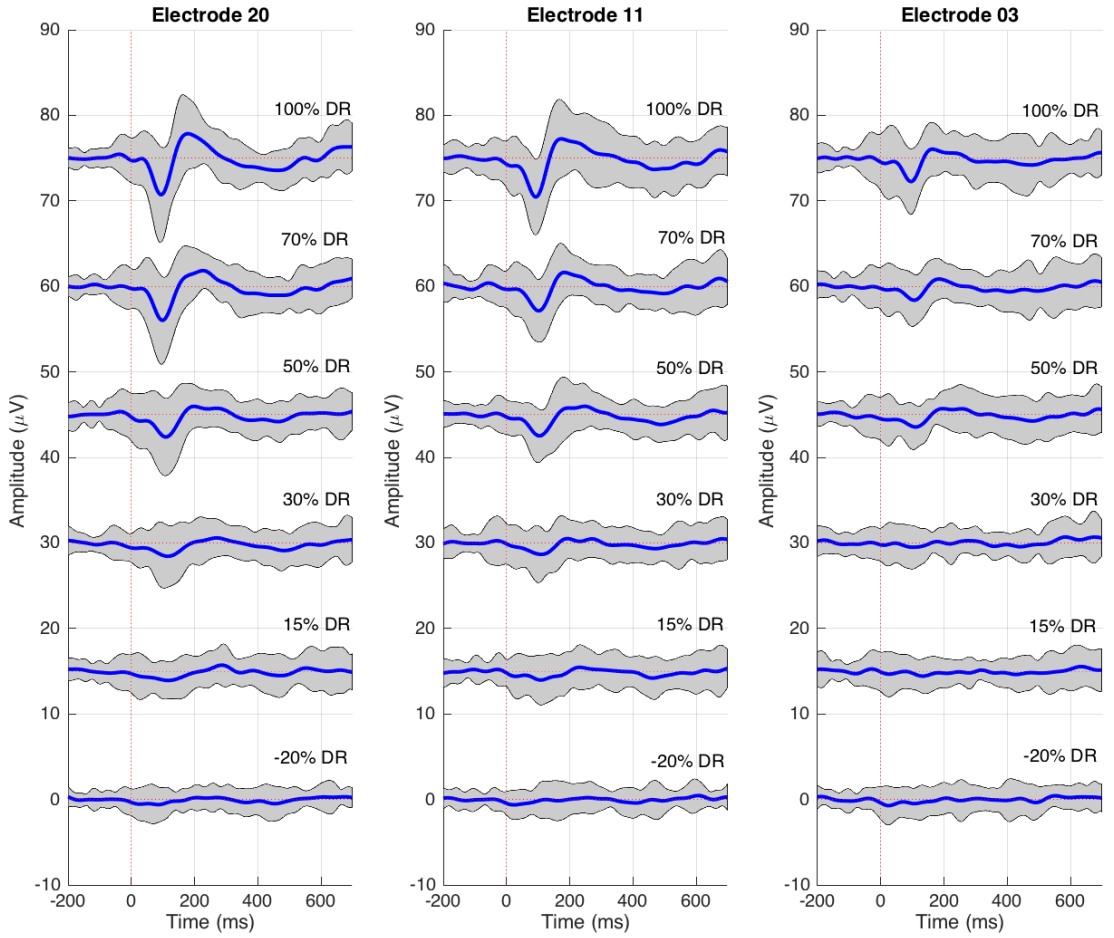
Results (3): Grand averages across 14 subjects

Before artefact suppression



32 out of 72 identifiable artefacts

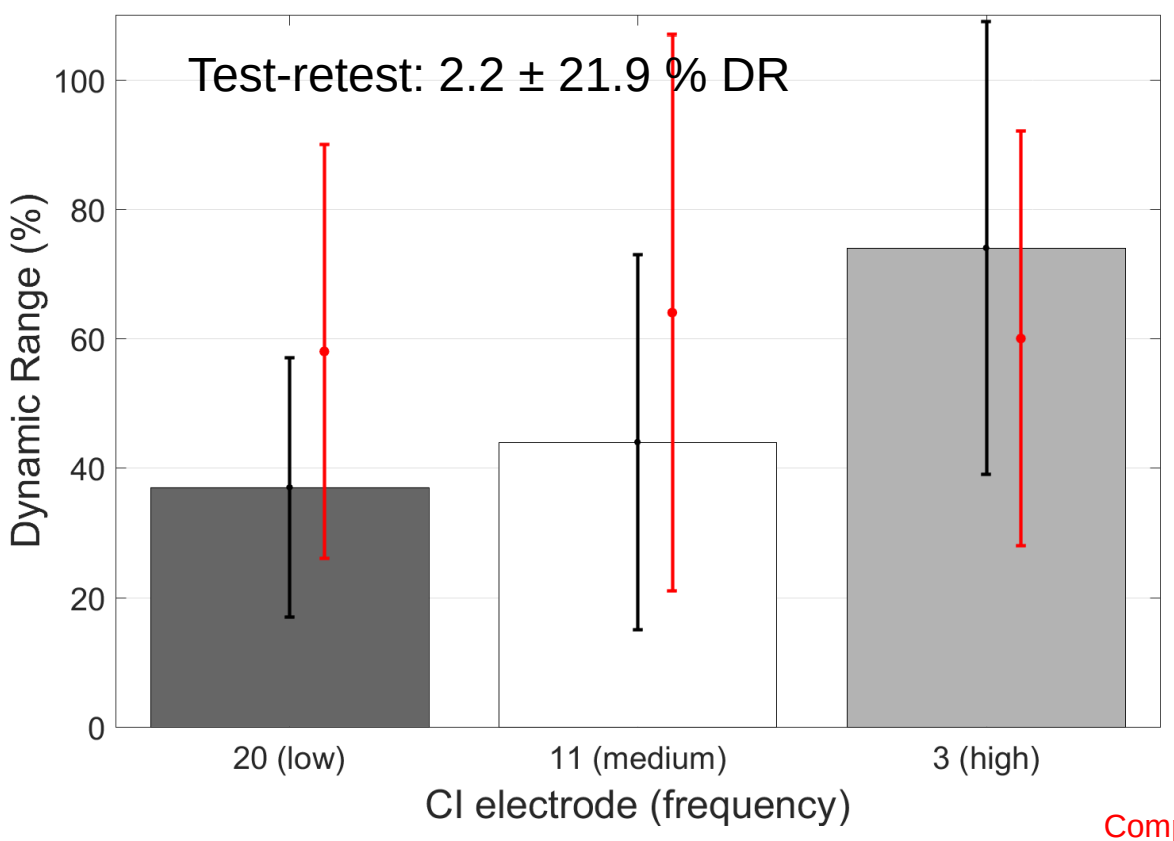
After artefact suppression



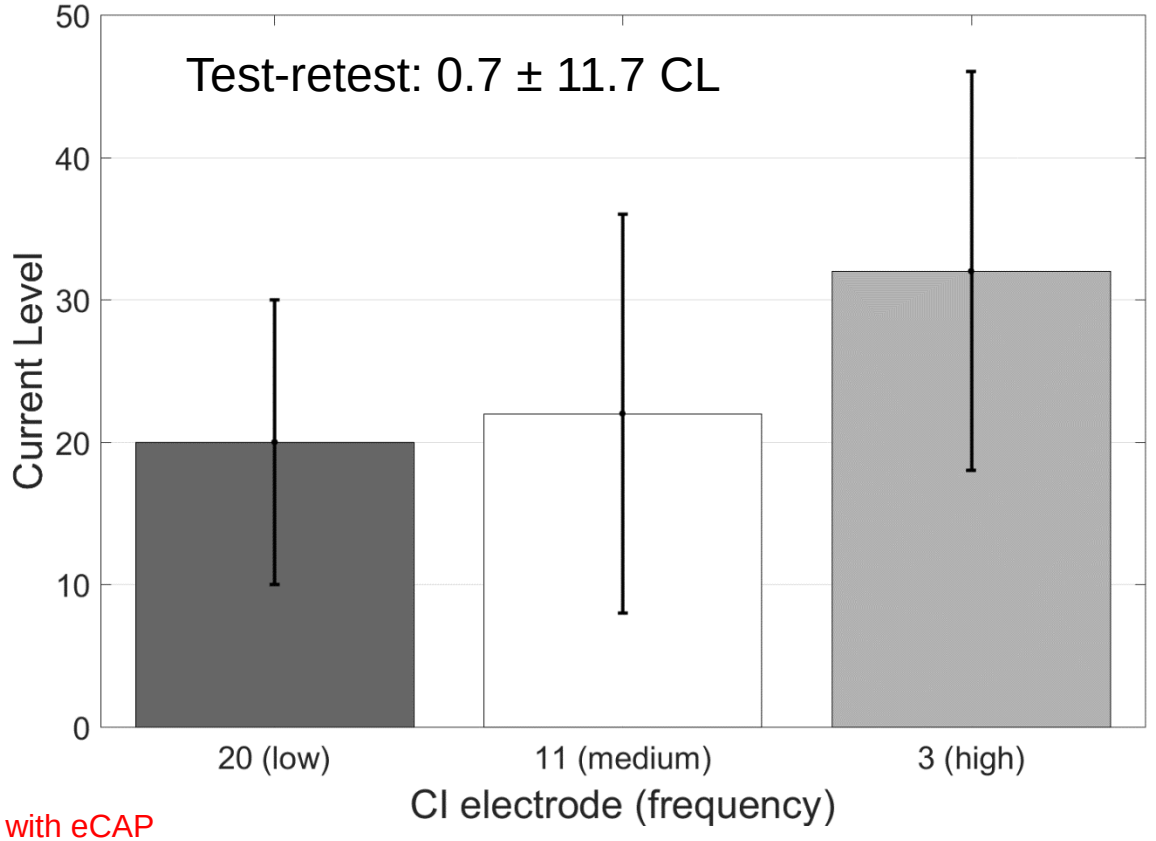
8 out of 72 identifiable artefacts

Results (4): Determining CI threshold using CAEPs

Dynamic range (DR)



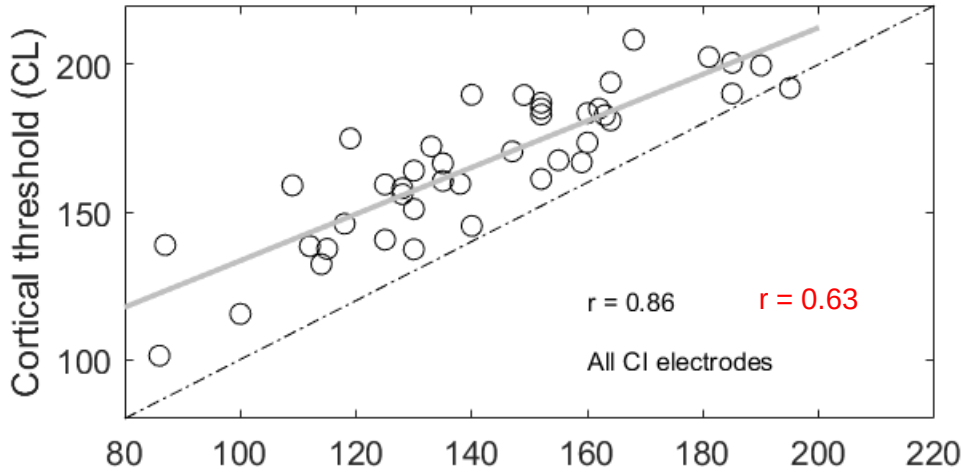
Current level (CL)

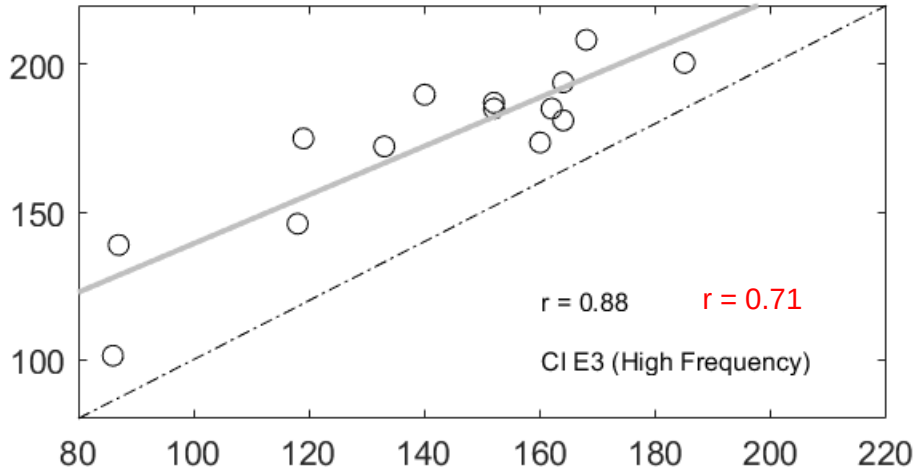


Compared with eCAP

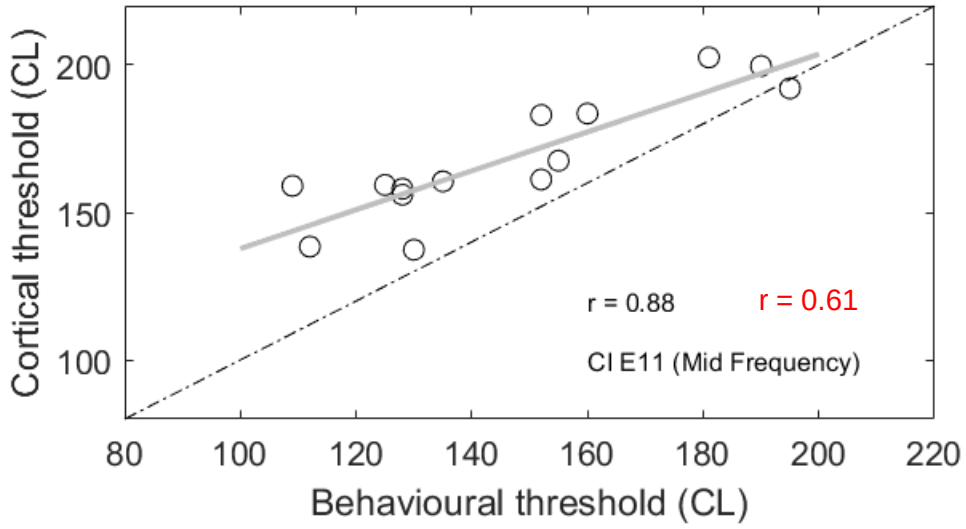
Not recordable in 2 subjects

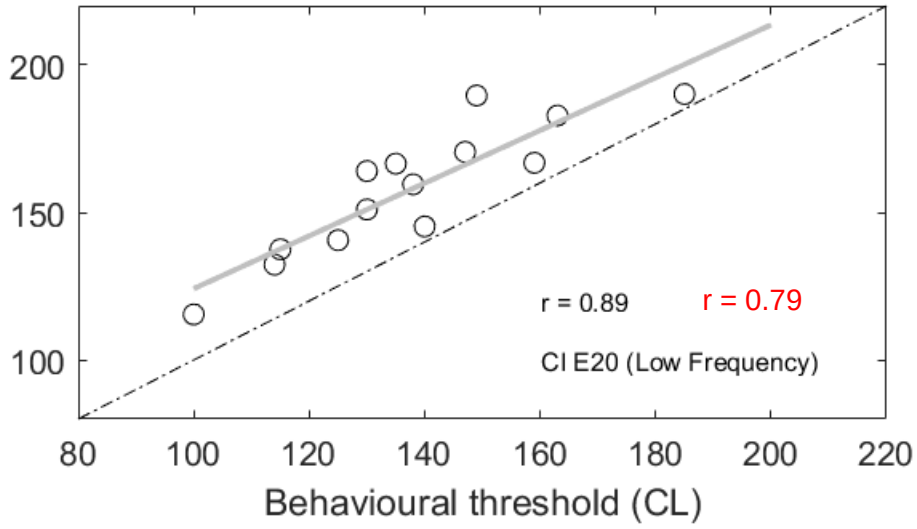
Results (5): Correlations with T-levels



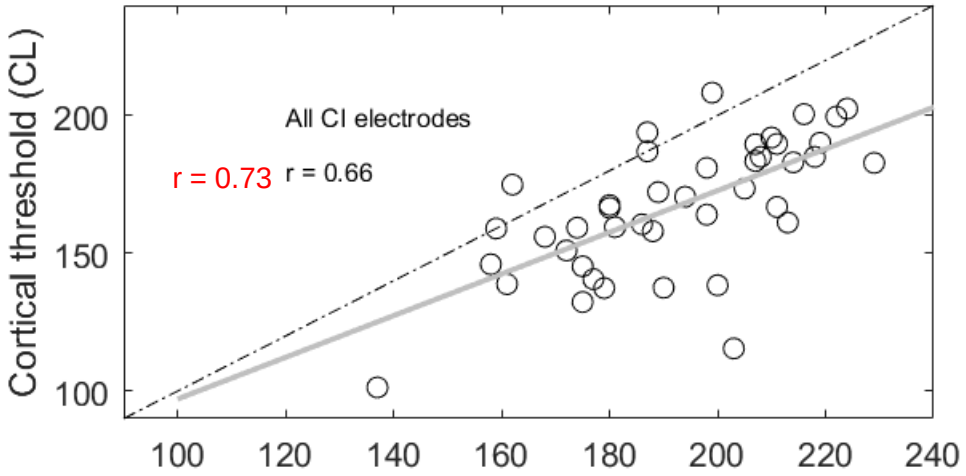


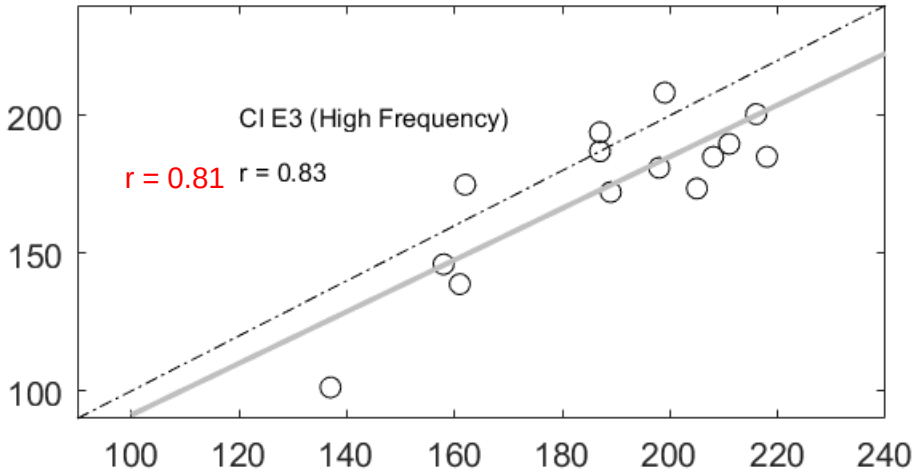
Compared with eCAP



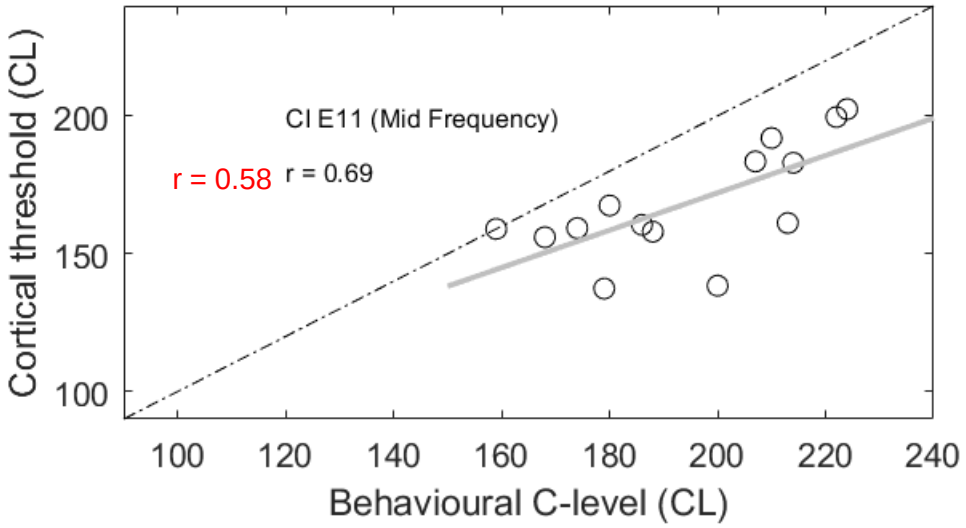


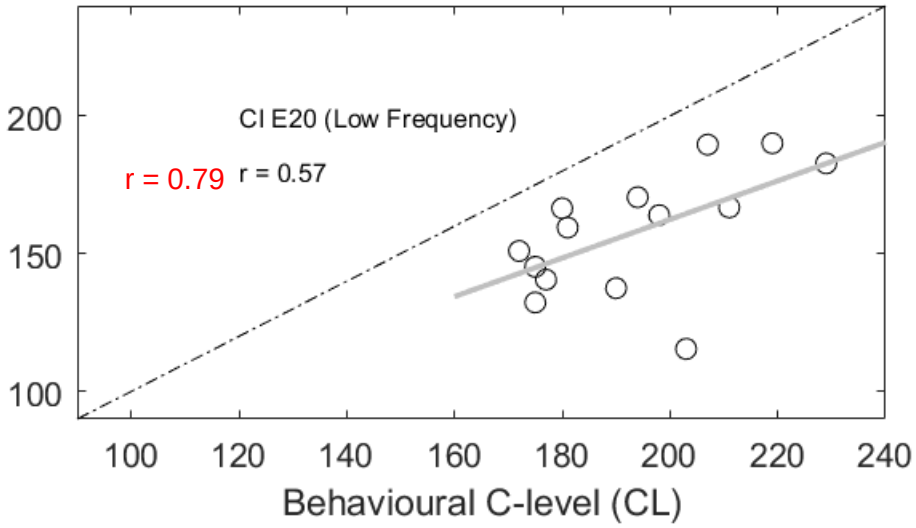
Results (6): Correlations with C-levels





Compared with eCAP





Conclusions

- Can we suppress CI artefacts sufficiently?
  - Yes, nice reduction of at least 3/4

- How much to correct a CAEP threshold for to obtain a T-level?
  - Depending on the stimulus, between 35 and 75% of dynamic range (SD 30%)
  - Test-retest reliability is excellent

- What are the correlations?
  - r = 0.86 for T-level
  - r = 0.66 for C-level

- How does this compare with the eCAP?
  - SDs for eCAPs are higher (30-45% DR)
  - r = 0.63 for T-level; r = 0.73 for C-level

This can all be done in a clinical recording device!

References

Brown, C. J. et al. (2000) "The relationship between EAP and EABR thresholds and levels used to program the Nucleus 24 speech processor: data from adults", Ear and Hearing, **21**(2), 151–163.

de Vos, J. J. et al. (2017) "Use of Electrically Evoked Compound Action Potentials for Cochlear Implant Fitting", Ear and Hearing, doi: 10.1097/AUD.0000000000000495.

Friesen, L. and T. W. Picton (2010) "A method for removing cochlear implant artefact" Hearing Research **259**: 95-106.

Gilley, P. M. et al. (2006) "Minimization of cochlear implant stimulus artifact in cortical auditory evoked potentials" Clinical Neurophysiology **117**(8): 1772-1782.

Mc Laughlin, M. et al. (2013) "Cochlear implant artifact attenuation in late auditory evoked potentials: A single channel approach" Hearing Research **302**: 84-95.

Presacco, A. et al. (2017) "Effects of stimulus duration on event-related potentials recorded from cochlear-implant users", Ear and Hearing, **38**(6), doi: 10.1097/AUD.0000000000000444.

Visram, A. S. et al. (2015) “Cortical auditory evoked potentials as an objective measure of behavioral thresholds in cochlear implant users” Hearing Research **327**: 35-42

Acknowledgements

- 14 CI participants
- SCIC (Sydney Cochlear Implant Centre): Rachelle Hassarati

Please also visit:

- hearlab.nal.gov.au
- www.hearnetlearning.org.au
- bram.vandun@nal.gov.au

This research was financially supported by the HEARing CRC established and supported under the Australian Government's Cooperative Research Centres Programme. The CRC Programme supports industry led end-user driven research collaborations to address the major challenges facing Australia.

Australian Government
Department of Industry, Innovation and Science
Business Cooperative Research Centres Programme

Members

MEMBER ORGANISATIONS

Australian Government
Department of Industry, Innovation and Science

Business Cooperative Research Centres Programme

The CRC Programme supports industry led end-user driven research collaborations to address the major challenges facing Australia.

Background

Cortical Auditory Evoked Potential (CAEP) thresholds in adults